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Research Report 1200

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A METHODOLOGY FOR CONDUCTING HUMAN FACTORS EVALUATIONS OF VEHICLES IN OPERATIONAL FIELD TESTS

John A. Hicks III

FORT HOOD FIELD UNIT

U. S. Army

Research Institute for the Behavioral and Social Sciences

August 1978

U. S. ARMY RESEARCH INSTITUTE

FOR THE BEHAVIORAL AND SOCIAL SCIENCES

A Field Operating Agency under the Jurisdiction of the Deputy Chief of Staff for Personnel

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NOTICES

Unclassified

SECURITY CLASSIFICATION OF THIS PAGE (*When Data Entered*)

REPORT DOCUMENTATION PAGE		READ INSTRUCTIONS BEFORE COMPLETING FORM
1. REPORT NUMBER Research Report 1200	2. GOVT ACCESSION NO.	3. RECIPIENT'S CATALOG NUMBER
4. TITLE (*and Subtitle*) 6 A METHODOLOGY FOR CONDUCTING HUMAN FACTORS EVALUATIONS OF VEHICLES IN OPERATIONAL FIELD TESTS.		5. TYPE OF REPORT & PERIOD COVERED 9 Final rept.
		6. ~~PERFORMING ORG.~~ REPORT NUMBER --
7. AUTHOR(s) 10 John A. Hicks, ~~III~~		8. CONTRACT OR GRANT NUMBER(s) --
9. PERFORMING ORGANIZATION NAME AND ADDRESS US Army Research Institute for the Behavioral and Social Sciences 5001 Eisenhower Avenue Alexandria, Virginia 22333		10. PROGRAM ELEMENT, PROJECT, TASK AREA & WORK UNIT NUMBERS 16 2Q763743A775
11. CONTROLLING OFFICE NAME AND ADDRESS Army Training and Doctrine Command Combined Arms Test Activity (TCATA) Fort Hood, Texas 76544		12. REPORT DATE 11 August 1978
		13. NUMBER OF PAGES 40
14. MONITORING AGENCY NAME & ADDRESS(*if different from Controlling Office*) 14 -- ARI-RR-1200		15. SECURITY CLASS. (*of this report*) Unclassified
		15a. DECLASSIFICATION/DOWNGRADING SCHEDULE

16. DISTRIBUTION STATEMENT (*of this Report*)

Approved for public release; distribution unlimited. 12 47p.

17. DISTRIBUTION STATEMENT (*of the abstract entered in Block 20, if different from Report*)

--

18. SUPPLEMENTARY NOTES

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19. KEY WORDS (*Continue on reverse side if necessary and identify by block number*)

Human factors engineering
Assessment and vehicles
Field test
Trucks
Vehicle test

20. ABSTRACT (*Continue on reverse side if necessary and identify by block number*)

The purpose was to develop a standardized methodology for use in conducting human factors evaluations of trucks and similar vehicles within the context of operational field tests. The focus is on the assessment of users' (drivers') judgments and allows for differential weighting of individual human factors characteristics. The key to the methodology is the Human Factors Vehicular Evaluation Instrument, which is an interview form containing 85 human factors characteristics relevant to vehicle design and operation. Data are presented from the initial utilization of the methodology in an operational field test.

DD FORM 1 JAN 73 1473 EDITION OF 1 NOV 65 IS OBSOLETE

Unclassified

SECURITY CLASSIFICATION OF THIS PAGE (*When Data Entered*)

408 010

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Department of the Army

August 1978

Army Project Number
2Q763743A775

Human Performance in
Field Assessment

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FOREWORD

The Fort Hood Field Unit of the Army Research Institute for the Behavioral and Social Sciences conducts research and provides technical advisory service for the Training and Doctrine Command Combined Arms Test Activity (TCATA). Headquarters, TCATA, via the submission of a Human Resources Need, had expressed the need for development of a basic standardized methodology for use in the conduct of human factors evaluations of trucks and similar vehicles in an operational environment. The present research was conducted in direct response to that statement of need. This report includes the presentation of a judgmental instrument for use in vehicular evaluations and a recommended evaluation methodology. The results of this research should be of use to all agencies conducting user tests of trucks and similar vehicles.

This research was executed under the project title "Human Performance in Field Assessment," which is part of Army Project 2Q763743A775.

JOSEPH ZEIDNER
Technical Director (Designate)

A METHODOLOGY FOR CONDUCTING HUMAN FACTORS EVALUATIONS OF VEHICLES IN OPERATIONAL FIELD TESTS

BRIEF

Requirement:

This research was conducted in direct response to a request from the Training and Doctrine Command (TRADOC) Combined Arms Test Activity (TCATA) for development of a standardized methodology for conducting human factors evaluations of trucks and similar vehicles in operational field tests. The purpose of the research was to develop such a methodology. The adoption of a standard list of human factors characteristics and evaluation methodology should preclude the need to establish a new list of characteristics and methodology for future operational field tests. The implementation of a standardized approach in future tests should allow reasonable comparisions among vehicles, even if the vehicles are not included in the same test.

Procedure:

Following a critical review of prior operational field tests of vehicles, an evaluation methodology was developed. The methodology focuses on the assessment of users' (drivers') judgments of the vehicles being evaluated and allows for the differential weighting of individual human factors characteristics. The key to the methodology is the Human Factors Vehicular Evaluation Instrument (HFVEI), which is an interview form containing 85 human factors characteristics relevant to vehicle design and operation.

The methodology was exercised during a phase of a TCATA operational field test that involved comparison of a nonstandard 3-1/2-ton cargo truck with both a standard U.S. Army 2-1/2-ton cargo truck and a standard U.S. Army 5-ton cargo truck. Twenty-nine licensed Army truck drivers were trained to drive all three types of vehicles. All of the drivers drove each type of vehicle around a 4-mile test course. The order in which the drivers drove the vehicles was counterbalanced. Immeidately after driving each type of vehicle, each driver was interviewed while seated in the cockpit of the vehicle and a HFVEI was completed. The drivers were also required to rate the relative importance (weight) of each of the 85 human factors characteristics. These ratings were used in determining importance weights for the characteristics.

Findings:

The methodology performed reasonably well during its initial utilization in the field. Six principal characteristics--driver compartment, visibility, controls and control operation, instruments, handling characteristics, and ride characteristics--were employed in making overall human factors comparisons among the three vehicles. A procedure was identified for assessing the impact of the differential weighting on the data.

The data analyses revealed that drivers judged the 3-1/2-ton and 5-ton vehicles to be significantly better than the 2-1/2-ton vehicle from an overall human factors standpoint. No significant difference was observed between drivers' judgments of the 3-1/2-ton and 5-ton vehicles. Post hoc analyses revealed that differences in the driving compartments, handling characteristics, and ride characteristics were largely responsible for the overall differences.

Utilization of Findings:

The evaluation methodology presented here should be of use to all agencies conducting user tests of trucks and similar vehicles.

A METHODOLOGY FOR CONDUCTING HUMAN FACTORS EVALUATIONS OF VEHICLES IN OPERATIONAL FIELD TESTS

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A METHODOLOGY FOR CONDUCTING HUMAN FACTORS EVALUATIONS OF VEHICLES IN OPERATIONAL FIELD TESTS

INTRODUCTION

A need exists within the U.S. Army operational field testing community for development of a standardized methodology for conducting human factors evaluations of trucks and similar vehicles. Various agencies, such as the U.S. Army Training and Doctrine Command Combined Arms Test Activity (TCATA), have conducted human factors evaluations of vehicles in operational field tests. Vehicles that have been evaluated range from those developed specifically for the U.S. Army to those developed for the commercial marketplace. Although common elements exist in these past human factors evaluations of vehicles, different lists of human factors vehicular characteristics and different evaluation methods have been used. Therefore, it is difficult to compare directly the results of investigations. Also, in many of these past investigations no attempt was made to establish weights (indexes of importance) for the individual characteristics.

The purpose of the present investigation was to develop a standardized methodology for use in conducting human factors evaluations of trucks and similar vehicles within the context of operational field tests. The methodology focuses on the assessment of users' (drivers') judgments of the human factors characteristics of the vehicles being evaluated and allows for differential weighting of individual characteristics. The development and adoption of a standard list of human factors characteristics and an evaluation methodology should preclude the need to establish a new list of characteristics and methodology for future operational field tests. The implementation of a standardized approach in future tests should allow reasonable comparisons among vehicles, even if the vehicles are not included in the same test.

RECOMMENDED HUMAN FACTORS EVALUATION METHODOLOGY

Initially, methodologies that had been used in prior operational field tests were critically reviewed. These methodologies were from the following tests: Berry (1975), which was a comparison of three U.S. Army cargo trucks; Berry et al. (1975), which was an evaluation of commercial tractors for use in transporting heavy equipment; and Thompson et al. (1976), which was a comparison of commercial vehicles for use in tactical military environments. Following review of prior tests and literature relevant to evaluation methodologies, a methodology was developed. It was anticipated that this methodology would be refined and perhaps modified following its utilization in the field.

Basically, the methodology involves the gathering of drivers' judgments of human factors characteristics of vehicles being evaluated. The methodology also involves the gathering of drivers' judgments of the importance (criticality) of the individual human factors characteristics. The methodology is primarily for use in evaluations involving more than one vehicle, but it can be modified for use in single-vehicle evaluations. The key to the methodology is the Human Factors Vehicular Evaluation Instrument (HFVEI) (see Appendix A), which was designed for use in an interview format. The HFVEI contains 85 human factors characteristics relevant to vehicle design and operation (see Table 1). The characteristics within the HFVEI are organized into six principal categories: driver compartment, visibility, controls and control operation, instruments, handling characteristics, and ride characteristics. Each category concludes with an overall characteristic relevant to that category. The following set of response alternatives is employed for each characteristic in the instrument:

+5 Extremely acceptable
+3 Acceptable
+1 Barely acceptable
-1 Barely unacceptable
-3 Unacceptable
-5 Extremely unacceptable

NO Not observed
NA Not applicable

Respondents to the instrument are instructed to assume that the points on the scale of acceptability/unacceptability define equal intervals, as indicated by the numbers associated with the verbal anchors.

The basic structure of the recommended methodology is as follows:

1. Select drivers to participate in the evaluation who are representative of the user or potential user population,

2. Train each driver to operate each vehicle and eliminate those drivers who cannot satisfy minimum performance standards with each vehicle (document the failures and, if possible, the reason for each failure),

3. Train the interviews who will be collecting data with the HFVEI and familiarize them with the evaluation procedures,

4. Familiarize the drivers with the HFVEI and the evaluation procedures,

5. Establish a test course that requires drivers to perform a variety of representative operational tasks with the vehicles over types of terrain appropriate for the vehicles being evaluated,

Table 1

Human Factors Vehicular Characteristics

Number	Vehicle characteristic
	I. DRIVER COMPARTMENT
	A. Entering and exiting from the cab
1	1. Effort required
	B. Driver's seat
2	1. Comfort and support
3	2. Driver's sitting position
4	3. Adjustment range and effort required to adjust
5	4. Overall evaluation
	C. Space
6	1. Space within the driver compartment
	D. Environmental conditions in the cab
7	1. Noise levels
8	2. Heating system
9	3. Ventilation system
10	4. Effort required to open and close windows
11	5. Overall evaluation
	E. Interior lighting (nighttime)
12	1. Adequacy for operation of controls
13	2. Adequacy for map reading or similar activities
14	3. Instrument lighting
15	4. Overall evaluation
	F. Safety
16	1. Safety of the vehicle's cab

(Continued)

*Summary characteristic for a principal category.

Table 1--Continued

Number	Vehicle characteristic
	G. Storage space
17	1. Adequacy for storing and securing equipment in the driving compartment
	H. Overall
*18	1. Overall evaluation of the driving compartment
	II. VISIBILITY
	A. Driver's front vision
19	1. Visibility
	B. Driver's rear vision
20	1. Visibility
	C. Driver's vision to the left
21	1. Visibility
	D. Driver's vision to the right
22	1. Visibility
	E. Mirrors
23	1. Adequacy
	F. Headlights (nighttime)
24	1. High beam effectiveness
25	2. Low beam effectiveness
	G. Windshield wipers
26	1. Effectiveness

(Continued)

*Summary characteristic for a principal category.

Table 1--Continued

Number	Vehicle characteristic
	H. Windshield defroster
27	1. Effectiveness
	I. Overall
*28	1. Overall evaluation of visibility
	III. CONTROLS AND CONTROL OPERATION
	A. Accelerator
29	1. Design, location, and effort required to operate
	B. Brake
30	1. Design, location, and effort required to operate
	C. Clutch/transmission
31	1. Design, location, and effort required to operate the clutch pedal
32	2. Design, location, and effort required to operate the gear shift lever
33	3. Gear shift pattern
	D. All wheel drive
34	1. Design, location, and effort required to operate
	E. Steering wheel
35	1. Design and location
36	2. Effort required to turn when stopped or at slow speeds (less than 15 mph)
37	3. Effort required to turn when driving at high speeds (greater than 15 mph)
38	4. Steering wheel vibration
	F. Emergency/parking brake
39	1. Design, location, and effort required to operate

(Continued)

Table 1--Continued

Number	Vehicle characteristic
	G. Lights
40	1. Design, location, and effort required to operate the headlights/parking lights control
41	2. Design, location, and effort required to operate the interior lights control
42	3. Design, location, and effort required to operate the headlights dimmer control
43	4. Design, location, and effort required to operate the turn signals
	H. Windshield wipers
44	1. Design, location, and effort required to operate
	I. Heater/ventilation
45	1. Design, location, and effort required to operate
	J. Starter
46	1. Design, location, and effort required to operate
	K. Choke
47	1. Design, location, and effort required to operate
	L. Overall
*48	1. Overall evaluation of the controls and control operation
	IV. INSTRUMENTS
	A. Speedometer/odometer
49	1. Design, location, and readability during vehicle operation

(Continued)

*Summary characteristic for a principal category.

Table 1--Continued

Number	Vehicle characteristic
	B. Tachometer
50	1. Design, location, and readability during vehicle operation
	C. Water temperature gage
51	1. Design, location, and readability during vehicle operation
	D. Oil pressure gage
52	1. Design, location, and readability during vehicle operation
	E. Fuel gage
53	1. Design, location, and readability during vehicle operation
	F. Battery charge/discharge gage
54	1. Design, location, and readability during vehicle operation
	G. Air pressure gage
55	1. Design, location, and readability during vehicle operation
	H. Overall
*56	1. Overall evaluation of the instrumentation
	V. HANDLING CHARACTERISTICS
	A. Cornering
57	1. Ability to corner at low speeds (less than 15 mph)

(Continued)

*Summary characteristic for a principal category.

Table 1--Continued

Number	Vehicle characteristic
58	2. Ability to corner at high speeds (greater than 15 mph)
59	3. Turning radius of vehicle
60	4. Overall evaluation of cornering ability
	B. <u>Road feel</u>
61	1. Ability to feel the road surface through the steering wheel
	C. <u>Braking</u>
62	1. Ability to make quick stops
63	2. Control of vehicle when braking
64	3. Effort required to stop the vehicle
65	4. Overall evaluation of the braking ability of the vehicle
	D. <u>Vehicle control</u> (maneuverability)
66	1. Controllability of the vehicle at low speeds (less than 15 mph) on a hard surface road
67	2. Controllability of the vehicle at high speeds (greater than 15 mph) on a hard surface road
68	3. Controllability of the vehicle at low speeds (less than 15 mph) off road
69	4. Controllability of the vehicle at high speeds (greater than 15 mph) off road
70	5. Safety hazards related to vehicle handling characteristics
71	6. Controllability of the vehicle while backing up to a loading dock
72	7. Controllability of the vehicle while parallel parking
73	8. Controllability of the vehicle during fording operations
74	9. Controllability of the vehicle while traversing mud or very soft ground
75	10. Controllability of the vehicle while operating on a steep slope
76	11. Overall evaluation of vehicle controllability

(Continued)

Table 1--Continued

Number	Vehicle characteristic
	E. Engine
77	1. Amount of engine power
78	2. Responsiveness of vehicle to accelerator inputs
79	3. Overall evaluation of engine performance
	F. Overall
*80	1. Overall evaluation of the vehicle handling characteristics
	VI. RIDE CHARACTERISTICS
	A. Ride quality
81	1. Quality of ride at low speeds (less than 15 mph) on a hard surface road
82	2. Quality of ride at high speeds (greater than 15 mph) on a hard surface road
83	3. Quality of the ride at low speeds (less than 15 mph) off road
84	4. Quality of ride at high speeds (greater than 15 mph) off road
	B. Overall
*85	1. Overall evaluation of the vehicle ride characteristics

*Summary characteristic for a principal category.

6. Have each driver operate each vehicle through the test course and counterbalance the order of driving the vehicles among the drivers,

7. Interview each driver and complete the HFVEI while the driver is still seated in the driver's seat following each run through the course,

8. Have the same interviewer conduct all of the interviews with a given driver,

9. After each driver has operated and rated each vehicle, have each driver rate the importance (criticality) of each of the human factors characteristics to mission accomplishment using a 10-point (0-9) equal-interval scale where zero is the rational zero point (a scale ranging from "not critical to mission accomplishment" to "very critical to mission accomplishment"), and

10. Analyze the data using analysis of variance (ANOVA) and post hoc multiple comparison techniques.

RECOMMENDED DATA ANALYSIS PROCEDURES

Data analysis procedures should be tailored to meet the specific needs of the evaluation. A Treatment-by-Subjects (Repeated-Measures) ANOVA can be employed to compare the vehicles under evaluation with respect to any or all of the 85 human factors characteristics. A separate ANOVA should be run for each comparison. If more than two vehicles are being compared when a significant difference is detected, a Duncan's Multiple Range Test or some other type of parametric post hoc multiple comparison test should be employed to further isolate the significant differences.

An overall human factors comparison among the vehicles under evaluation, without differential weighting of characteristics, can be achieved by summing each driver's ratings of the six principal characteristics for each vehicle and analyzing this set of summed ratings with a Treatment-by-Subjects ANOVA. If the ANOVA reveals a significant difference among vehicles, a Duncan's Multiple Range Test can be employed for analysis of pairwise comparisons.

Differential weighting of the six principal characteristics can be achieved by use of the drivers' ratings of the importance of each characteristic. A mean importance weight should be calculated for each of the six characteristics. These mean weights can then be multiplied, respectively, by each driver's rating of the six characteristics for each vehicle. Next, the weighted drivers' ratings can be summed and analyzed in the same manner as described previously for the unweighted drivers' ratings (i.e., using a Treatment-by-Subjects ANOVA and a Duncan's Multiple Range Test).

An important consideration to be addressed in the data analysis is whether use of the differential weighting has any significant impact on the overall vehicle comparisons. Ghiselli and Brown (1955) suggest use of a coefficient of correlation between the equally weighted and differentially weighted summed ratings as an index of the effectiveness of the differential weighting. If the coefficient is very high, the weighting system adds nothing; if the coefficient is moderate or low, the weighting

system can be said to significantly affect the overall ratings. Ghiselli and Brown also note that in most instances where several rating scales (characteristics) are used, the conditions are such that application of differential weights will have little effect. They point out that, mathematically, the correlation coefficient becomes higher under the following conditions: the greater the number of traits (characteristics) being rated, the higher the intercorrelations among ratings of the different traits and the more similar the weights given different traits. Therefore, it is recommended that a correlation coefficient be calculated between the unweighted and differentially weighted summed ratings. If the coefficient is high, the differential weighting should not be employed in the data analysis.

EXERCISE OF THE METHODOLOGY

The recommended human factors evaluation methodology was first used during a phase of TCATA Test FM 372, Foreign Vehicle Evaluation (Morin et al., 1977). The test involved the comparison of a nonstandard 3-1/2-ton cargo truck (truck A) with both a standard U.S. Army 2-1/2-ton cargo truck (truck B) and a standard U.S. Army 5-ton cargo truck (truck C). Twenty-nine licensed Army truck drivers, including 8 E-2's, 7 E-3's, 13 E-4's and 1 E-5, were trained to drive all three types of vehicles. All of the drivers drove each type of vehicle around a 4-mile test course. The order in which the drivers drove through the course was counterbalanced. Immediately after driving each type of vehicle, each driver was interviewed while seated in the driver's seat of the vehicle, and a HFVEI was completed.

The drivers were previously required to rate the relative importance of each of the 85 human factors characteristics. This was accomplished by presenting a deck of 85 cards to each driver. One characteristic was printed on each card. Each driver was required to sort the cards into seven categories, where the first category was labeled "not critical to mission accomplishment" and the seventh category was labeled "very critical to mission accomplishment." The order of the cards was randomized for each driver.

A Treatment-by-Subjects ANOVA revealed that application of the mean importance weights to the drivers' ratings of the vehicles did not have any significant impact on the overall vehicle ratings. (See the Technical Supplement to this report.) Therefore, the decision was made not to employ the differential weighting in the data analysis.

The mean summed ratings for the three vehicles are presented in Table 2. The data analyses indicated that the drivers judged trucks A and C to be significantly better than truck B from an overall human factors standpoint ($F(2, 56) = 9.26$; $p < .001$). Differences in the ratings

Table 2

Drivers' Summed Ratings Over the Six Principal Characteristics

Driver	Vehicle		
	Truck A	Truck B	Truck C
1	20	20	20
2	18	8	10
3	16	16	16
4	14	12	18
5	20	14	14
6	26	24	24
7	6	6	6
8	20	8	16
9	18	14	16
10	18	16	18
11	18	18	18
12	18	-8	8
13	18	6	14
14	22	22	24
15	18	16	18
16	22	18	18
17	18	20	20
18	18	14	18
19	14	8	14
20	-6	-4	-2
21	18	18	18
22	20	18	18
23	18	16	18
24	12	14	18
25	30	14	16
26	6	6	12
27	18	14	14
28	18	18	20
29	18	18	18
Mean	17.03	13.24	15.86

Note. The entries in the table represent the summation for a given vehicle of an individual driver's ratings of the six principal characteristics without differential weighting of characteristics.

of the driver compartment, handling characteristics, and ride characteristics were largely responsible for these overall differences. No significant difference was observed in the drivers' judgments of trucks A and C.

OBSERVATIONS AND COMMENTARY

Overall, the methodology performed reasonably well during its initial utilization in the field. If the set of mean differential weights determined for the six principal characteristics in this investigation proves similar to the sets of weights determined in future investigations involving comparable subject populations (i.e., Army truck drivers), it is unlikely that use of differential weighting will prove worthwhile. Results from subsequent investigations should help resolve this issue.

Results of a human factors evaluation must be assessed from the proper perspective. Within the context of an operational field test of vehicles, a human factors evaluation of the hardware represents an important, yet singular, dimension of the overall field evaluation process. Other dimensions often include, but are not limited to, hardware performance, reliability, maintainability, safety, training requirements, and cost.

A dominant aspect of an operational field test is that the hardware being tested is placed in the hands of personnel who are assumed to be representative of the population of potential users. When a human factors comparison of hardware is based upon user judgments or opinions, it is important to recognize that users often lack the sensitivity, sophistication, or frame of reference necessary to detect subtle differences in the human factors characteristics of the hardware. Often, subtle differences are not detected because the pieces of hardware being compared were designed for a common purpose and user population. Therefore, an analyst should not feel compelled to detect differences in the user judgments, for frequently no "real" differences exist. When statistically significant differences in user judgments or ratings are observed, a determination of the practical significance of the differences must be rendered. In conducting human factors comparisons of hardware, it is just as important to document reports of no significant differences as it is to document reports of significant differences.

The methodology presented in this report should provide a standard framework for future human factors evaluations of vehicles in operational field tests. Although human factors characteristics can be added to or deleted from the list of 85 characteristics to meet specific needs of future tests, the six principal characteristics should provide an adequate basis for overeall human factors assessment.

PRIMARY DATA ANALYSES

The drivers' summed ratings over the six principal characteristics without differential weighting yielded means of 17.03, 13.04, and 15.86 for trucks A, B, and C, respectively (see Table 2). The mean and variance of drivers' ratings by characteristic are presented in Table 3. Table 4 contains the drivers' mean importance weights for the six principal characteristics.

The intercorrelations among drivers' ratings of the characteristics across vehicles ranged from a high of .61 to a low of .28, with a mean of .44 (see Table 5). Based upon the use of six characteristics, the relatively high intercorrelations among the ratings of the characteristics, and the similarity of the weights given the characteristics, Ghiselli and Brown's (1955) guidelines suggested that application of the differential weights would not affect the overall ratings. When the mean weights were applied, the correlation coefficient between the unweighted and weighted summed ratings was equal to .99. Therefore, because the differential weighting apparently did not significantly affect the overall vehicle ratings, the decision was made not to employ the differential weights in the data analysis. Note that a 7-point scale was employed to determine the importance weights, rather than the 10-point scale recommended earlier. Use of the 10-point scale may have increased the spread among the weights, but because of the relatively high intercorrelations among the ratings of the characteristics, it is unlikely that use of the 10-point scale would have altered the decision not to employ the weights in the data analysis.

A Treatment-by-Subjects ANOVA was conducted on the drivers' summed ratings over the six principal characteristics. The analysis yielded a significant main effect for vehicles ($F(2, 56) = 9.26$, $p < .001$, η^2 (eta squared) = 0.06). A Duncan's Multiple Range Test further revealed that the mean summed ratings for trucks A and C were not significantly different from each other, but the mean summed rating for trucks A and C was significantly higher ($p < .01$) than the mean summed rating for truck B. To better assess the contribution of each characteristic to the overall significant difference among vehicles, a separate Treatment-by-Subjects ANOVA and Duncan's Multiple Range Test were calculated for each of the six characteristics. The results from these analyses are presented in Table 6.

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Table 3

Mean and Variance of Drivers' Ratings by Characteristic

Principal characteristic	Mean	Variance
Driver compartment	2.13	2.76
Visibility	2.63	1.91
Controls and control operation	2.79	1.58
Instruments	2.91	2.04
Handling characteristics	2.54	2.48
Ride characteristics	2.38	2.26

Table 4

Drivers' Mean Importance Weight by Characteristic

Characteristic	Mean importance weight
Driving compartment	3.63
Visibility	4.07
Controls and control operation	3.37
Instruments	3.17
Handling characteristics	3.87
Ride characteristics	3.17

Table 5

Intercorrelations Among Drivers' Ratings of the Six Principal Characteristics

Characteristic	(1) Driving compartment	(2) Visibility	(3) Controls and control operation	(4) Instruments	(5) Handling characteristics	(6) Ride characteristics
(1)	--	.61	.42	.46	.50	.45
(2)		--	.44	.38	.45	.54
(3)			--	.58	.33	.28
(4)				--	.35	.30
(5)					--	.56

Table 6

Mean Vehicle Ratings and Duncan's Multiple Range Test Results by Characteristic for Drivers' Ratings

Characteristic	Mean vehicle rating: Truck A	Truck B	Truck C	Results from Duncan's Multiple Range Test[a]
Driver compartment	2.66	1.76	1.96	B C A $p < .05$
Visibility	2.93	2.38	2.59	B C A No difference
Controls and control operation	3.07	2.59	2.72	B C A No difference
Instruments	2.93	2.86	2.93	B C A No difference
Handling characteristics	2.79	1.69	3.14	B A C $p < .005$
Ride characteristics	2.66	1.96	2.52	B C A $p < .10$

[a]The letters represent a rank ordering of the mean ratings from low to high. Means underlined by a common line do not differ significantly.

In summary, the data analyses revealed that the drivers judged trucks A and C to be significantly better than truck B from an overall human factors standpoint. Differences in the driver compartment, handling characteristics, and ride characteristics were largely responsible for these results.

SUPPLEMENTARY DATA ANALYSES

This section includes supplemental analyses of data collected during the field exercise of the human factors evaluation methodology.

Comparison of Alternative Techniques for Establishing Importance Weights

Earlier in this report, it was recommended that the means of drivers' ratings of importance be used for establishing differential weighting of the human factors characteristics. This method was compared with two alternative methods of assigning importance weights. One alternative was to employ the medians, rather than the means, of drivers' ratings of importance. The other alternative involved use of a psychological scaling procedure to establish a set of importance weights.

The scaling procedure used was the method of successive intervals, as described by Edwards and Thurstone (1952). According to these authors, the method of successive intervals is a psychological scaling procedure in which stimuli are classified into successive intervals based on the degree of some defined attribute they are judged to possess. In the present application of the method, the 85 human factors characteristics served as the stimuli and degree of importance served as the judged attribute. Application of the method required the use of drivers' judgments (ratings) of the importance of all 85 human factors characteristics.

The technique involves the formation of cumulative percentage distributions of judgments for each characteristic, conversion of the cumulative percentages to Z scores, construction of a matrix of differences of Z scores, and determination of estimates of the width of successive scale intervals. This procedure is accomplished by averaging the Z scores across the 85 characteristics for each scale interval. After the scale (i.e., the psychological continuum) is established, a scale value is determined for each of the 85 characteristics by linear interpolation of the median judgment of each characteristic onto the scale. The technique is based upon the assumption that distributions of judgments for each characteristic (stimulus) are normal on the psychological continuum as defined.

Each method of weighting the characteristics was employed to produce a set of weights that included an importance weight for each of the 85 human factors characteristics. The intercorrelations among these three sets of weights (see Table 7) revealed strong similarities among the weights. The three sets of weights for the six principal characteristics are presented in Table 8. The intercorrelations among these reduced sets of weights also revealed strong similarities among the weights (see Table 9).

Overall, these analyses reflected minimal differences in the importance weights established using the three methods. Based on this finding and the relative ease of calculating mean weights, the mean weighting technique was included in the recommended evaluation methodology.

Table 7

Intercorrelations Among Alternative Sets of Drivers' Importance Weights for All 85 Characteristics

	(1) Mean weights	(2) Median weights	(3) Scale value weights
(1)	--	.90	.95
(2)		--	.96

Table 8

Comparison of Alternative Methods of Assigning Importance Weights

Characteristic	Mean weights	Median weights	Scale values
Driving compartment	3.63	4.0	.76
Visibility	4.07	4.5	.97
Controls and control operation	3.37	3.5	.43
Instruments	3.17	3.5	.43
Handling characteristics	3.87	5.0	1.04
Ride characteristics	3.17	3.5	.43

Table 9

Intercorrelations Among Alternative Sets of Drivers' Importance Weights for the Six Principal Characteristics

	(1) Mean weights	(2) Median weights	(3) Scale value weights
(1)	--	.94	.95
(2)		--	.96

Analyses of Interviewers' Data

Seven individuals served as interviewers during the phase of the TCATA operational field test in which the human factors evaluation methodology was exercised. All of the interviewers were experienced truck drivers (six E-5's and one E-6). At the conclusion of the test, each of the interviewers completed an HFVEI for each truck and rated the relative importance of each of the 85 human factors characteristics.

The interviewers' mean summed ratings over the six principal characteristics without any differential weighting yielded means of 19.71, 12.57, and 16.86 for trucks A, B, and C, respectively (see Table 10). The mean and variance of interviewers' ratings by characteristic are shown in Table 11.

Table 12 contains the interviewers' and drivers' mean importance weights for the six principal characteristics. A comparison of these two sets of importance weights yielded a moderately sized correlation coefficient equal to .59. When the interviewers' mean weights were applied to the interviewers' summed ratings, the correlation coefficient between the unweighted and weighted summed ratings was equal to .99. Therefore, because application of the differential weighting did not significantly affect the overall vehicle ratings, the decision was made not to employ the differential weights in the data analysis.

Table 10

Interviewers' Summed Ratings
Over the Six Principal Characteristics

Interviewer	Vehicle Truck A	Truck B	Truck C
1	20	14	18
2	18	12	24
3	16	2	8
4	28	20	22
5	20	14	16
6	18	12	16
7	18	14	14
Mean	19.71	12.57	16.86

Note. The entries in the table represent the summation for a given vehicle of an individual interviewer's ratings of the six principal characteristics without differential weighting of characteristics.

Table 11

Mean and Variance of Interviewers' Ratings
by Characteristic

Principal characteristic	Mean	Variance
Driver compartment	1.62	1.05
Visibility	2.19	.76
Controls and control operation	1.90	.99
Instruments	2.10	.99
Handling characteristics	1.52	4.76
Ride characteristics	1.05	4.25

Table 12

Comparison of Interviewers' and Drivers' Importance Weights of the Six Principal Characteristics

Characteristic	Interviewers' mean importance weight	Drivers' mean importance weight
Driving compartment	2.14	3.63
Visibility	4.43	4.07
Controls and control operation	3.00	3.37
Instruments	2.71	3.17
Handling characteristics	3.86	3.87
Ride characteristics	3.43	3.17

A Treatment-by-Subjects ANOVA was conducted on the interviewers' summed ratings over the six principal characteristics. The analysis yielded a significant main effect for vehicles ($F\ (2,\ 12) = 11.29$, $p < .005$, η^2 (eta squared) = 0.30). A Duncan's Multiple Range Test further revealed that the mean summed rating for truck A was significantly higher than the mean summed rating for truck C ($p < .10$), and that the mean summed rating for truck C was significantly higher than the mean summed rating for truck B ($p < .05$). In other words, all the comparisons among the three means yielded statistically significant differences. To better assess the contribution of each principal characteristic to the overall significant differences among vehicles, a separate Treatment-by-Subjects ANOVA and Duncan's Multiple Range Test were calculated for each of the six characteristics. The results from these analyses are presented in Table 13.

Table 13

Mean Vehicle Ratings and Duncan's Multiple Range Test Results by Characteristic for Interviewers' Ratings

Characteristic	Mean vehicle rating			Results from Duncan's Multiple Range Test[a]
	Truck A	Truck B	Truck C	
Driver compartment	3.29	1.86	2.71	B C C $p < .05$
Visibility	3.29	2.71	3.57	B A C No difference
Controls and control operation	3.29	2.71	2.71	B C A No difference
Instruments	3.29	3.00	3.00	B C A No difference
Handling characteristics	3.57	1.00	2.00	B C A $p < .05$
Ride characteristics	3.00	1.29	1.86	B C A $p < .05$

[a]The letters represent a rank ordering of the mean ratings from low to high. Means underlined by a common line do not differ significantly.

Overall, findings from analyses of the interviewers' data were consistent with findings from analyses of the drivers' data. From an overall human factors viewpoint, the interviewers judged truck C to be significantly better than truck A and truck A to be significantly better than truck B. Differences in the driving compartment, handling characteristics, and ride characteristics appeared to be largely responsible for these results. The strong correspondence between findings from the interviewers' and drivers' data provided additional support for the conclusions drawn from analyses of the drivers' data.

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APPENDIX

HUMAN FACTORS VEHICULAR EVALUATION INSTRUMENT

INSTRUCTIONS

Please rate the test vehicle which you have just driven with respect to the vehicle characteristics which follow. Some characteristics contain information enclosed in parenthesis. This information should be used in understanding the meaning of the individual characteristics. Please circle the appropriate rating value for each characteristic. Use the following rating scheme, which is repeated at the top of each page:

+5 - Extremely acceptable
+3 - Acceptable
+1 - Barely acceptable
-1 - Barely unacceptable
-3 - Unacceptable
-5 - Extremely unacceptable
NO - Not Observed
NA - Not Applicable

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-5 - Extremely unacceptable
-3 - Unacceptable
-1 - Barely unacceptable
NO - Not Observed

+5 - Extremely acceptable
+3 - Acceptable
+1 - Barely acceptable
NA - Not Applicable

	VEHICLE CHARACTERISTIC	RATING
	I. DRIVER COMPARTMENT	
	A. <u>Entering and Exiting from the cab</u>	
1	1. Effort required (height above ground, speed, size and shape of opening, adequacy of hand-holds and steps)	-5 -3 -1 +1 +3 +5 NO NA
	B. <u>Driver's seat</u>	
2	1. Comfort and support (lower back support, side-to-side support)	-5 -3 -1 +1 +3 +5 NO NA
3	2. Driver's sitting position (angle, posture)	-5 -3 -1 +1 +3 +5 NO NA
4	3. Adjustment range and effort required to adjust	-5 -3 -1 +1 +3 +5 NO NA
5	4. Overall evaluation of the driver's seat	-5 -3 -1 +1 +3 +5 NO NA
	C. <u>Space</u>	
6	1. Space within the driver compartment (head room, leg room, hip room, shoulder room)	-5 -3 -1 +1 +3 +5 NO NA
	D. <u>Environmental conditions in the cab</u>	
7	1. Noise levels in the cab	-5 -3 -1 +1 +3 +5 NO NA
8	2. Heating system in the cab (temperature levels)	-5 -3 -1 +1 +3 +5 NO NA
9	3. Ventilation system in the cab (temperature levels)	-5 -3 -1 +1 +3 +5 NO NA
10	4. Effort required to open and close windows in the cab	-5 -3 -1 +1 +3 +5 NO NA

-5 - Extremely unacceptable	+5 - Extremely acceptable
-3 - Unacceptable	+3 - Acceptable
-1 - Barely unacceptable	+1 - Barely acceptable
NO - Not Observed	NA - Not Applicable

	VEHICLE CHARACTERISTIC	RATING							
11	5. Overall evaluation of environmental conditions in the cab	-5	-3	-1	+1	+3	+5	NO	NA
	E. <u>Interior lighting</u> (nighttime)								
12	1. Adequacy for operation of controls (brightness, adjustability)	-5	-3	-1	+1	+3	+5	NO	NA
13	2. Adequacy for map reading or similar activities during night operations (brightness, adjustability)	-5	-3	-1	+1	+3	+5	NO	NA
14	3. Instrument lighting	-5	-3	-1	+1	+3	+5	NO	NA
15	4. Overall evaluation of interior lighting in the cab	-5	-3	-1	+1	+3	+5	NO	NA
	F. <u>Safety</u>								
16	1. Safety of the vehicle's cab (freedom from sharp corners, knobs and levers, adequacy of seat belts, adequacy of the horn, rollover protection)	-5	-3	-1	+1	+3	+5	NO	NA
	G. <u>Storage space</u>								
17	1. Adequacy of space for storing and securing equipment in the driving compartment	-5	-3	-1	+1	+3	+5	NO	NA
	H. <u>Overall</u>								
*18	1. Overall evaluation of the driving compartment	-5	-3	-1	+1	+3	+5	NO	NA
	II. VISIBILITY								
	A. <u>Driver's front vision</u>								
19	1. Visibility (freedom from glare, field of view)	-5	-3	-1	+1	+3	+5	NO	NA

-5 - Extremely unacceptable
-3 - Unacceptable
-1 - Barely unacceptable
NO - Not Observed

+5 - Extremely acceptable
+3 - Acceptable
+1 - Barely acceptable
NA - Not Applicable

	VEHICLE CHARACTERISTIC	RATING							
	B. <u>Driver's rear vision</u>								
20	1. Visibility (freedom from glare, field of view)	-5	-3	-1	+1	+3	+5	NO	NA
	C. <u>Driver's vision to the left</u>								
21	1. Visibility (freedom from glare, field of view)	-5	-3	-1	+1	+3	+5	NO	NA
	D. <u>Driver's vision to the right</u>								
22	1. Visibility (freedom from glare, field of view)	-5	-3	-1	+1	+3	+5	NO	NA
	E. <u>Mirrors</u>								
23	1. Adequacy (number, size, location, adjustability, blind spots, freedom from vibration)	-5	-3	-1	+1	+3	+5	NO	NA
	F. <u>Headlights</u> (nighttime)								
24	1. High beam effectiveness	-5	-3	-1	+1	+3	+5	NO	NA
25	2. Low beam effectiveness	-5	-3	-1	+1	+3	+5	NO	NA
	G. <u>Windshield wipers</u>								
26	1. Effectiveness of windshield wipers	-5	-3	-1	+1	+3	+5	NO	NA
	H. <u>Windshield defroster</u>								
27	1. Effectiveness of windshield defroster	-5	-3	-1	+1	+3	+5	NO	NA
	I. <u>Overall</u>								
*28	1. Overall evaluation of visibility	-5	-3	-1	+1	+3	+5	NO	NA

-5 - Extremely unacceptable	+5 - Extremely acceptable
-3 - Unacceptable	+3 - Acceptable
-1 - Barely unacceptable	+1 - Barely acceptable
NO - Not Observed	NA - Not Applicable

	VEHICLE CHARACTERISTIC	RATING
	III. CONTROLS AND CONTROL OPERATION	
	A. Accelerator	
29	1. Design, location and effort required to operate the accelerator pedal (size, shape, reach distance)	-5 -3 -1 +1 +3 +5 NO NA
	B. Brake	
30	1. Design, location and effort required to operate the brake pedal (size, shape, reach distance)	-5 -3 -1 +1 +3 +5 NO NA
	C. Clutch/transmission	
31	1. Design, location and effort required to operate the clutch pedal (size, shape, reach distance)	-5 -3 -1 +1 +3 +5 NO NA
32	2. Design, location and effort required to operate the gear shift lever (size, shape, reach distance)	-5 -3 -1 +1 +3 +5 NO NA
33	3. Gear shift pattern (complexity)	-5 -3 -1 +1 +3 +5 NO NA
	D. All wheel drive	
34	1. Design, location and effort required to operate the all wheel drive control (size, shape, reach distance)	-5 -3 -1 +1 +3 +5 NO NA
	E. Steering wheel	
35	1. Design and location of the steering wheel (position, angle, size, shape, reach distance)	-5 -3 -1 +1 +3 +5 NO NA

-5 - Extremely unacceptable	+5 - Extremely acceptable
-3 - Unacceptable	+3 - Acceptable
-1 - Barely unacceptable	+1 - Barely acceptable
NO - Not Observed	NA - Not Applicable

		VEHICLE CHARACTERISTIC	RATING
36	2.	Effort required to turn the steering wheel when stopped or at slow speeds	-5 -3 -1 +1 +3 +5 NO NA
37	3.	Effort required to turn the steering wheel when driving at high speeds (greater than 15 mph)	-5 -3 -1 +1 +3 +5 NO NA
38	4.	Steering wheel vibration	-5 -3 -1 +1 +3 +5 NO NA
	F.	<u>Emergency/parking brake</u>	
39	1.	Design, location and effort required to operate the emergency/parking brake control (size, shape, reach distance)	-5 -3 -1 +1 +3 +5 NO NA
	G.	<u>Lights</u>	
40	1.	Design, location and effort required to operate the headlights/parking lights control (size, shape, reach distance)	-5 -3 -1 +1 +3 +5 NO NA
41	2.	Design, location and effort required to operate the interior lights control (size, shape, reach distance)	-5 -3 -1 +1 +3 +5 NO NA
42	3.	Design, location and effort required to operate the headlights dimmer control (size, shape, reach distance)	-5 -3 -1 +1 +3 +5 NO NA
43	4.	Design, location and effort required to operate the turn signals (size, shape, reach distance)	-5 -3 -1 +1 +3 +5 NO NA

-5 - Extremely unacceptable	+5 - Extremely acceptable
-3 - Unacceptable	+3 - Acceptable
-1 - Barely unacceptable	+1 - Barely acceptable
NO - Not Observed	NA - Not Applicable

	VEHICLE CHARACTERISTIC	RATING
	H. Windshield wipers	
44	1. Design, location and effort required to operate the windshield wiper control (size, shape, reach distance)	-5 -3 -1 +1 +3 +5 NO NA
	I. Heater/ventilation	
45	1. Design, location and effort required to operate the heater/ventilation controls (size, shape, reach distance)	-5 -3 -1 +1 +3 +5 NO NA
	J. Starter	
46	1. Design, location and effort required to operate the starter control (size, shape, reach distance)	-5 -3 -1 +1 +3 +5 NO NA
	K. Choke	
47	1. Design, location and effort required to operate the choke control (size, shape, reach distance)	-5 -3 -1 +1 +3 +5 NO NA
	L. Overall	
48	1. Overall evaluation of the controls and control operation	-5 -3 -1 +1 +3 +5 NO NA
	IV. INSTRUMENTS	
	A. Speedometer/odometer	
49	1. Design, location and readability during vehicle operation (vision unobstructed, scale markings, labelling, size)	-5 -3 -1 +1 +3 +5 NO NA

-5 - Extremely unacceptable	+5 - Extremely acceptable
-3 - Unacceptable	+3 - Acceptable
-1 - Barely unacceptable	+1 - Barely acceptable
NO - Not Observed	NA - Not Applicable

	VEHICLE CHARACTERISTIC	RATING
	B. Tachometer	
50	1. Design, location and readability during vehicle operation (vision unobstructed, scale markings, labelling, size)	-5 -3 -1 +1 +3 +5 NO NA
	C. Water temperature gauge	
51	1. Design, location and readability during vehicle operation (vision unobstructed, scale markings, labelling, size)	-5 -3 -1 +1 +3 +5 NO NA
	D. Oil pressure gauge	
52	1. Design, location and readability during vehicle operation (vision unobstructed, scale markings, labelling, size)	-5 -3 -1 +1 +3 +5 NO NA
	E. Fuel gauge	
53	1. Design, location and readability during vehicle operation (vision unobstructed, scale markings, labelling, size)	-5 -3 -1 +1 +3 +5 NO NA
	F. Battery charge/discharge gauge	
54	1. Design, location and readability during vehicle operation (vision unobstructed, scale markings, labelling, size)	-5 -3 -1 +1 +3 +5 NO NA
	G. Air pressure gauge	
55	1. Design, location and readability during vehicle operation (vision unobstructed, scale markings, labelling, size)	-5 -3 -1 +1 +3 +5 NO NA

-5 - Extremely unacceptable
-3 - Unacceptable
-1 - Barely unacceptable
NO - Not Observed

+5 - Extremely acceptable
+3 - Acceptable
+1 - Barely acceptable
NA - Not Applicable

	VEHICLE CHARACTERISTIC	RATING
	H. Overall	
*56	1. Overall evaluation of the instrumentation	-5 -3 -1 +1 +3 +5 NO NA
	V. HANDLING CHARACTERISTICS	
	A. Cornering	
57	1. Ability to corner at low speeds (less than 15 mph)	-5 -3 -1 +1 +3 +5 NO NA
58	2. Ability to corner at high speeds (greater than 15 mph)	-5 -3 -1 +1 +3 +5 NO NA
59	3. Turning radius of vehicle	-5 -3 -1 +1 +3 +5 NO NA
60	4. Overall evaluation of cornering ability	-5 -3 -1 +1 +3 +5 NO NA
	B. Road feel	
61	1. Ability to feel the road surface through the steering wheel	-5 -3 -1 +1 +3 +5 NO NA
	C. Braking	
62	1. Ability to make quick stops	-5 -3 -1 +1 +3 +5 NO NA
63	2. Control of vehicle (directional stability) when braking (weaving, rear end breaking loose)	-5 -3 -1 +1 +3 +5 NO NA
64	3. Effort required to stop the vehicle	-5 -3 -1 +1 +3 +5 NO NA
65	4. Overall evaluation of braking ability of vehicle	-5 -3 -1 +1 +3 +5 NO NA
	D. Vehicle control (maneuverability)	
66	1. Controllability of the vehicle at low speeds (less than 15 mph) on a hard surface road	-5 -3 -1 +1 +3 +5 NO NA

-5 - Extremely unacceptable | +5 - Extremely acceptable
-3 - Unacceptable | +3 - Acceptable
-1 - Barely unacceptable | +1 - Barely acceptable
NO - Not Observed | NA - Not Applicable

		VEHICLE CHARACTERISTIC	RATING							
67	2.	Controllability of the vehicle at high speeds (greater than 15 mph) on a hard surface road	-5	-3	-1	+1	+3	+5	NO	NA
68	3.	Controllability of the vehicle at low speeds (less than 15 mph) off road	-5	-3	-1	+1	+3	+5	NO	NA
69	4.	Controllability of the vehicle at high speeds (greater than 15 mph) off road	-5	-3	-1	+1	+3	+5	NO	NA
70	5.	Safety hazards related to vehicle handling characteristics (instability)	-5	-3	-1	+1	+3	+5	NO	NA
71	6.	Controllability of the vehicle while backing up to a loading dock	-5	-3	-1	+1	+3	+5	NO	NA
72	7.	Controllability of the vehicle while parallel parking	-5	-3	-1	+1	+3	+5	NO	NA
73	8.	Controllability of the vehicle during fording operations	-5	-3	-1	+1	+3	+5	NO	NA
74	9.	Controllability of the vehicle while traversing mud or very soft ground	-5	-3	-1	+1	+3	+5	NO	NA
75	10.	Controllability of the vehicle while operating on a steep slope	-5	-3	-1	+1	+3	+5	NO	NA
76	11.	Overall evaluation of vehicle controllability	-5	-3	-1	+1	+3	+5	NO	NA
	E.	<u>Engine</u>								
77	1.	Amount of engine power	-5	-3	-1	+1	+3	+5	NO	NA
78	2.	Responsiveness of vehicle to accelerator inputs	-5	-3	-1	+1	+3	+5	NO	NA

-5 - Extremely unacceptable	+5 - Extremely acceptable
-3 - Unacceptable	+3 - Acceptable
-1 - Barely unacceptable	+1 - Barely acceptable
NO - Not Observed	NA - Not Applicable

	VEHICLE CHARACTERISTIC	RATING							
79	3. Overall evaluation of engine performance	-5	-3	-1	+1	+3	+5	NO	NA
	F. Overall								
*80	1. Overall evaluation of the vehicle handling characteristics	-5	-3	-1	+1	+3	+5	NO	NA
	VI. RIDE CHARACTERISTICS								
	A. Ride quality (freedom from up-down, side-to-side, and front-to-back vibrations; smoothness; stability)								
81	1. Quality of ride at low speeds (less than 15 mph) on a hard surface road	-5	-3	-1	+1	+3	+5	NO	NA
82	2. Quality of ride at high speeds (greater than 15 mph) on a hard surface road	-5	-3	-1	+1	+3	+5	NO	NA
83	3. Quality of ride at low speeds (less than 15 mph) off road	-5	-3	-1	+1	+3	+5	NO	NA
84	4. Quality of ride at high speeds (greater than 15 mph) off road	-5	-3	-1	+1	+3	+5	NO	NA
	B. Overall								
*85	1. Overall evaluation of the vehicle ride characteristics	-5	-3	-1	+1	+3	+5	NO	NA

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1 US WAC Ctr & Sch, Ft McClellan, ATTN: Lib
1 US WAC Ctr & Sch, Ft McClellan, ATTN: Tng Dir
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1 USA Armor Sch, Ft Knox, ATTN: Library
1 USA Armor Sch, Ft Knox, ATTN: ATSB-DI-E
1 USA Armor Sch, Ft Knox, ATTN: ATSB-DT-TP
1 USA Armor Sch, Ft Knox, ATTN: ATSB-CD-AD
2 HQUSACDEC, Ft Ord, ATTN: Library
1 HQUSACDEC, Ft Ord, ATTN: ATEC-EX-E-Hum Factors
2 USAEEC, Ft Benjamin Harrison, ATTN: Library
1 USAPACDC, Ft Benjamin Harrison, ATTN: ATCP-HR
1 USA Comm-Elect Sch, Ft Monmouth, ATTN: ATSN-EA
1 USAEC, Ft Monmouth, ATTN: AMSEL-CT-HDP
1 USAEC, Ft Monmouth, ATTN: AMSEL-PA-P
1 USAEC, Ft Monmouth, ATTN: AMSEL-SI-CB
1 USAEC, Ft Monmouth, ATTN: C. Facl Dev B.
1 USA Materials Sys Anal Agcy, Aberdeen, ATTN: AMXSY-P
1 Edgewood Arsenal, Aberdeen, ATTN: SAREA-BL-H
1 USA Ord Ctr & Sch, Aberdeen, ATTN: ATSL-TEM-C
2 USA Hum Engr Lab, Aberdeen, ATTN: Library/Dir
1 USA Combat Arms Tng Bd, Ft Benning, ATTN: Ad Supervisor
1 USA Infantry Hum Rsch Unit, Ft Benning, ATTN: Chief
1 USA Infantry Bd, Ft Benning, ATTN: STEBC-TE-T
1 USASMA, Ft Bliss, ATTN: ATSS-LRC
1 USA Air Def Sch, Ft Bliss, ATTN: ATSA-CTD-ME
1 USA Air Def Sch, Ft Bliss, ATTN: Tech Lib
1 USA Air Def Bd, Ft Bliss, ATTN: FILES
1 USA Air Def Bd, Ft Bliss, ATTN: STEBD-PO
1 USA Cmd & General Stf College, Ft Leavenworth, ATTN: Lib
1 USA Cmd & General Stf College, Ft Leavenworth, ATTN: ATSW-SE-L
1 USA Cmd & General Stf College, Ft Leavenworth, ATTN: Ed Advisor
1 USA Combined Arms Cmbt Dev Act, Ft Leavenworth, ATTN: DepCdr
1 USA Combined Arms Cmbt Dev Act, Ft Leavenworth, ATTN: CCS
1 USA Combined Arms Cmbt Dev Act, Ft Leavenworth, ATTN: ATCASA
1 USA Combined Arms Cmbt Dev Act, Ft Leavenworth, ATTN: ATCACO-E
1 USA Combined Arms Cmbt Dev Act, Ft Leavenworth, ATTN: ATCACC-CI
1 USAECOM, Night Vision Lab, Ft Belvoir, ATTN: AMSEL-NV-SD
3 USA Computer Sys Cmd, Ft Belvoir, ATTN: Tech Library
1 USAMERDC, Ft Belvoir, ATTN: STSFB-DQ
1 USA Eng Sch, Ft Belvoir, ATTN: Library
1 USA Topographic Lab, Ft Belvoir, ATTN: ETL-TD-S
1 USA Topographic Lab, Ft Belvoir, ATTN: STINFO Center
1 USA Topographic Lab, Ft Belvoir, ATTN: ETL-GSL
1 USA Intelligence Ctr & Sch, Ft Huachuca, ATTN: CTD-MS
1 USA Intelligence Ctr & Sch, Ft Huachuca, ATTN: ATS-CTD-MS
1 USA Intelligence Ctr & Sch, Ft Huachuca, ATTN: ATSI-TE
1 USA Intelligence Ctr & Sch, Ft Huachuca, ATTN: ATSI-TEX-GS
1 USA Intelligence Ctr & Sch, Ft Huachuca, ATTN: ATSI-CTS-OR
1 USA Intelligence Ctr & Sch, Ft Huachuca, ATTN: ATSI-CTD-DT
1 USA Intelligence Ctr & Sch, Ft Huachuca, ATTN: ATSI-CTD-CS
1 USA Intelligence Ctr & Sch, Ft Huachuca, ATTN: DAS/SRD
1 USA Intelligence Ctr & Sch, Ft Huachuca, ATTN: ATSI-TEM
1 USA Intelligence Ctr & Sch, Ft Huachuca, ATTN: Library
1 CDR, HQ Ft Huachuca, ATTN: Tech Ref Div
2 CDR, USA Electronic Prvg Grd, ATTN: STEEP-MT-S
1 CDR, Project MASSTER, ATTN: Tech Info Center
1 Hq MASSTER, USATRADOC, LNO
1 Research Institute, HQ MASSTER, Ft Hood
1 USA Recruiting Cmd, Ft Sherdian, ATTN: USARCPM-P
1 Senior Army Adv., USAFAGOD/TAC, Elgin AF Aux Fld No. 9
1 HQ USARPAC, DCSPER, APO SF 96558, ATTN: GPPE-SE
1 Stimson Lib, Academy of Health Sciences, Ft Sam Houston
1 Marine Corps Inst., ATTN: Dean-MCI
1 HQUSMC, Commandant, ATTN: Code MTMT 51
1 HQUSMC, Commandant, ATTN: Code MPI-20
2 USCG Academy, New London, ATTN: Admission
2 USCG Academy, New London, ATTN: Library
1 USCG Training Ctr, NY, ATTN: CO
1 USCG Training Ctr, NY, ATTN: Educ Svc Ofc
1 USCG, Psychol Res Br, DC, ATTN: GP 1/62
1 HQ Mid-Range Br, MC Det, Quantico, ATTN: P&S Div

1 US Marine Corps Liaision Ofc, AMC, Alexandria, ATTN: AMCGS–F
1 USATRADOC, Ft Monroe, ATTN: ATRO–ED
6 USATRADOC, Ft Monroe, ATTN: ATPR–AD
1 USATRADOC, Ft Monroe, ATTN: ATTS–EA
1 USA Forces Cmd, Ft McPherson, ATTN: Library
2 USA Aviation Test Bd, Ft Rucker, ATTN: STEBG–PO
1 USA Agcy for Aviation Safety, Ft Rucker, ATTN: Library
1 USA Agcy for Aviation Safety, Ft Rucker, ATTN: Educ Advisor
1 USA Aviation Sch, Ft Rucker, ATTN: PO Drawer O
1 HQUSA Aviation Sys Cmd, St Louis, ATTN: AMSAV–ZDR
2 USA Aviation Sys Test Act., Edwards AFB, ATTN: SAVTE–T
1 USA Air Def Sch, Ft Bliss, ATTN: ATSA TEM
1 USA Air Mobility Rsch & Dev Lab, Moffett Fld, ATTN: SAVDL–AS
1 USA Aviation Sch, Res Tng Mgt, Ft Rucker, ATTN: ATST–T–RTM
1 USA Aviation Sch, CO, Ft Rucker, ATTN: ATST–D–A
1 HQ, DARCOM, Alexandria, ATTN: AMXCD–TL
1 HQ, DARCOM, Alexandria, ATTN: CDR
1 US Military Academy, West Point, ATTN: Serials Unit
1 US Military Academy, West Point, ATTN: Ofc of Milt Ldrshp
1 US Military Academy, West Point, ATTN: MAOR
1 USA Standardization Gp, UK, FPO NY, ATTN: MASE–GC
1 Ofc of Naval Rsch, Arlington, ATTN: Code 452
3 Ofc of Naval Rsch, Arlington, ATTN: Code 458
1 Ofc of Naval Rsch, Arlington, ATTN: Code 450
1 Ofc of Naval Rsch, Arlington, ATTN: Code 441
1 Naval Aerospc Med Res Lab, Pensacola, ATTN: Acous Sch Div
1 Naval Aerospc Med Res Lab, Pensacola, ATTN: Code L51
1 Naval Aerospc Med Res Lab, Pensacola, ATTN: Code L5
1 Chief of NavPers, ATTN: Pers-OR
1 NAVAIRSTA, Norfolk, ATTN: Safety Ctr
1 Nav Oceanographic, DC, ATTN: Code 6251, Charts & Tech
1 Center of Naval Anal, ATTN: Doc Ctr
1 NavAirSysCom, ATTN: AIR–5313C
1 Nav BuMed, ATTN: 713
1 NavHelicopterSubSqua 2, FPO SF 96601
1 AFHRL (FT) William AFB
1 AFHRL (TT) Lowry AFB
1 AFHRL (AS) WPAFB, OH
2 AFHRL (DOJZ) Brooks AFB
1 AFHRL (DOJN) Lackland AFB
1 HQUSAF (INYSD)
1 HQUSAF (DPXXA)
1 AFVTG (RD) Randolph AFB
3 AMRL (HE) WPAFB, OH
2 AF Inst of Tech, WPAFB, OH, ATTN: ENE/SL
1 ATC (XPTD) Randolph AFB
1 USAF AeroMed Lib, Brooks AFB (SUL–4), ATTN: DOC SEC
1 AFOSR (NL), Arlington
1 AF Log Cmd, McClellan AFB, ATTN: ALC/DPCRB
1 Air Force Academy, CO, ATTN: Dept of Bel Scn
5 NavPers & Dev Ctr, San Diego
2 Navy Med Neuropsychiatric Rsch Unit, San Diego
1 Nav Electronic Lab, San Diego, ATTN: Res Lab
1 Nav TrngCen, San Diego, ATTN: Code 9000–Lib
1 NavPostGraSch, Monterey, ATTN: Code 55Aa
1 NavPostGraSch, Monterey, ATTN: Code 2124
1 NavTrngEquipCtr, Orlando, ATTN: Tech Lib
1 US Dept of Labor, DC, ATTN: Manpower Admin
1 US Dept of Justice, DC, ATTN: Drug Enforce Admin
1 Nat Bur of Standards, DC, ATTN: Computer Info Section
1 Nat Clearing House for MH–Info, Rockville
1 Denver Federal Ctr, Lakewood, ATTN: BLM
12 Defense Documentation Center
4 Dir Psych, Army Hq, Russell Ofcs, Canberra
1 Scientific Advsr, Mil Bd, Army Hq, Russell Ofcs, Canberra
1 Mil and Air Attache, Austrian Embassy
1 Centre de Recherche Des Facteurs, Humaine de la Defense Nationale, Brussels
2 Canadian Joint Staff Washington
1 C/Air Staff, Royal Canadian AF, ATTN: Pers Std Anal Br
3 Chief, Canadian Def Rsch Staff, ATTN: C/CRDS(W)
4 British Def Staff, British Embassy, Washington
1 Def & Civil Inst of Enviro Medicine, Canada
1 AIR CRESS, Kensington, ATTN: Info Sys Br
1 Militaerpsykologisk Tjeneste, Copehagen
1 Military Attache, French Embassy, ATTN: Doc Sec
1 Medecin Chef, C.E.R.P.A.–Arsenal, Toulon/Naval France
1 Prin Scientific Off, Appl Hum Engr Rsch Div, Ministry of Defense, New Delhi
1 Pers Rsch Ofc Library, AKA, Israel Defense Forces
1 Ministeris van Defensie, DOOP/KL Afd Sociaal Psychologische Zaken, The Hague, Netherlands